



The Basics of Troubleshooting in Plastics Processing

An Introductory Practical Guide

**Muralisrinivasan Natamai
Subramanian**



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**Muralisrinivasan Natamai
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Contents

Preface	xiii
1. Introduction	1
1.1 Market Trends	2
1.2 Importance of Plastics	3
1.2.1 Plastics vs Metal	4
1.2.2 Plastics vs Paper and Paper Board	5
1.3 Plastics Processing	5
1.4 Fundamentals	6
References	6
2. Plastics Materials	9
2.1 Properties and Processing	11
2.1.1 Molecular Weight	12
2.1.2 Molecular Weight Distribution (MWD)	12
2.1.3 Flow Properties	12
2.1.4 Degree of Crystallinity	13
2.1.5 Surface Quality	13
2.1.6 Viscosity	13
2.2 Polyethylene	13
2.3 Polypropylene (PP)	16
2.4 Polystyrene	18
2.5 Polyvinylchloride (PVC)	18
2.6 Engineering Plastics	20
2.6.1 Acrylonitrile Butadiene Styrene (ABS)	21
2.6.2 Polymethylmethacrylate (PMMA)	22
2.6.3 Nylon	24
2.6.4 Polyethyleneterephthalate (PET)	25

2.6.5	Polycarbonate (PC)	27
2.6.6	Polyether Ether Ketone (PEEK)	27
2.6.7	Polytetrafluoroethylene (PTFE)	29
2.6.8	Polyacetal (POM)	30
2.6.9	Polyvinylidene Fluoride (PVDF)	31
2.6.10	Polyphenylene Sulfide (PPS)	32
2.7	Advantages	32
2.8	Fundamentals	32
	References	33
3.	Plastics Additives	41
3.1	Antioxidants	42
3.2	Anti-block Agents	43
3.3	Antistatic Agent	43
3.4	Clarifying Agents	44
3.5	Slip Additives	44
3.6	Processing Aids	44
3.7	Antifogging Agents	45
3.8	Antiblocking Agents	45
3.9	Heat Stabilizers	46
3.10	Lubricants	47
3.11	Plasticizers	48
3.12	Coupling Agents or Surface Modifiers	48
3.13	Release Agents	49
3.14	Flame Retardants	49
3.15	Pigments	49
3.16	Light Stabilizers	50
3.17	Impact Modifiers	50
3.18	Blowing Agents	52
3.19	Nucleating Agents	52
3.20	Biocides	53
3.21	Fillers	53
3.22	Fundamentals	56
	References	56
4.	Plastics Processing	61
4.1	Focus on Plastics Processing	62
4.2	Injection Molding	63
4.2.1	Injection Molding – Machine	64

4.2.1.1	Ram Injection Molding Machine	64
4.2.1.2	Screw Injection Molding Machine	64
4.2.2	Injection Unit	64
4.2.2.1	Barrel	65
4.2.2.2	Screw	66
4.2.2.3	Clamping Unit	67
4.2.2.4	Hydraulic Unit	67
4.2.3	Mold	68
4.2.3.1	Gate	71
4.2.3.2	Runner	72
4.2.3.3	Sprue	73
4.2.3.4	Cavity	73
4.2.3.5	Nozzle	73
4.2.3.6	Vent	74
4.2.3.7	Ejection System	74
4.2.4	Injection Molding and Parameters	74
4.2.4.1	Temperature	75
4.2.4.2	Pressure	77
4.2.4.3	Time	78
4.2.4.4	Cooling	80
4.2.4.5	Velocity	82
4.2.4.6	Part Design	83
4.2.5	Injection Molding – Processing	83
4.2.6	Process Variables	84
4.2.6.1	Cushion	86
4.2.6.2	Shot Size	86
4.2.7	Advantages	86
4.2.8	Shortcomings	87
4.3	Extrusion	87
4.3.1	Extrusion – Basic Requirements	88
4.3.2	Extruder	90
4.3.2.1	Single Screw Extruder	91
4.3.2.2	Twin Screw Extruder	92
4.3.2.3	Feeder	93
4.3.2.4	Screw	94
4.3.2.5	Die	95
4.3.3	Polymer Melt	96
4.3.4	Extrudate Swell	97
4.3.5	Extrusion and Process Parameters	98

4.3.6	Extrusion – Processing	100
4.3.7	Advantages	104
4.3.8	Shortcomings	104
4.4	Blow Molding	105
4.4.1	Blow Molding and Process Parameters	105
4.4.2	Extrusion Blow Molding	106
4.4.3	Injection Stretch Blow Molding	107
4.4.4	Advantages	110
4.4.5	Shortcomings	110
4.5	Thermoforming	110
4.5.1	Thermoforming and Parameters	111
4.5.2	Processing	112
4.5.3	Mold	112
4.5.4	Advantages	113
4.5.5	Shortcomings	114
4.6	Rotational Molding	114
4.6.1	Rotational Molding and Parameters	114
4.6.2	Mold	116
4.6.3	Processing	116
4.6.4	Pigmentation	118
4.6.5	Advantages	119
4.6.6	Shortcomings	119
4.7	Fundamentals	119
4.7.1	Injection Molding	119
4.7.2	Extrusion	120
4.7.3	Blow Molding	120
4.7.4	Thermoforming	121
4.7.5	Rotational Molding	122
	References	122
5.	Troubleshooting – Problems and Solutions	133
5.1	Troubleshooting – Requirements	135
5.2	Injection Molding – Troubleshooting	136
5.2.1	Part Sticking in Cavities	140
5.2.2	Part Sticking in Core	141
5.2.3	Discoloration	141
5.2.4	Burnt Marks (Diesel Effect)	143
5.2.5	Part Sticks During Ejection	143
5.2.6	Jetting	144

5.2.7	Dimensions Out of Specification	144
5.2.8	Bubbles	146
5.2.9	Internal Voids	146
5.2.10	Flash (Over Substrate or on Periphery of Part)	147
5.2.11	Poor Weld Line	149
5.2.12	Low Gloss/Gloss Difference	150
5.2.13	Overmold Breaks/Impinges Through Hollow Substrate	151
5.2.14	Warpage or Warped Parts	152
5.2.15	Splay Marks/Delamination	152
5.2.16	Flow Marks, Folds and Back Fills	153
5.2.17	Ejector Pin Marks	155
5.2.18	Sink Marks	155
5.2.19	Shrinkage	156
5.2.20	Silver Streak	158
5.2.21	Short Shots	158
5.2.22	Brittle Part	159
5.2.23	Poor Plasticizing	160
5.2.24	Crack During Mold Release	160
5.2.25	Nozzle Drool	162
5.2.26	Short Shots no Burn Marks	162
5.2.27	Surface Ripples, and Pit Marks	163
5.2.28	Pellets not Melted	163
5.2.29	Air Entrapment in the Mold	165
5.2.30	Gate Blush	166
5.3	Troubleshooting – Extrusion	167
5.3.1	“Bridging” at the Throat of the Feed Hopper	167
5.3.2	Brittle/Braking/Tearing	168
5.3.3	Contamination/Black Specks and Spots	169
5.3.4	Die Lines	170
5.3.5	Entrapped Gasses/Air Bubbles	170
5.3.6	Excessive Die Swell	170
5.3.7	Material Accumulation at Die	172
5.3.8	Low Gloss	172
5.3.9	Material Non-Homogeneous	172
5.3.10	Variable Thickness	174
5.3.11	Variable Output/Surging	174
5.3.12	Plate-Out on Die Lip	176

5.4	Troubleshooting – Blow molding	176
5.4.1	Extrusion Blow Molding	177
5.4.1.1	Curling	177
5.4.1.2	Hooking	178
5.4.1.3	Inconsistent Tail Length	178
5.4.1.4	Blowouts or Pin Holes	178
5.4.1.5	Poor Wall Thickness	
	Distribution (Top to Bottom)	180
5.4.1.6	Asymmetric Part	180
5.4.1.7	Poor Weld	180
5.4.1.8	Poor Parting Line	181
5.4.1.9	Contamination in Parts	182
5.4.1.10	Flashing Tear	182
5.4.1.11	Holes in Pinch-Offs	182
5.4.1.12	Blowouts	182
5.4.2	Injection Blow Molding	185
5.4.2.1	Poor Gates	
	(Fish Eyes, Flash, Tails, etc.)	185
5.4.2.2	Poor Gates	185
5.4.2.3	Rocker Bottoms	186
5.4.2.4	Incomplete Thread	186
5.4.2.5	Pig Tails	186
5.4.2.6	Short Shots	188
5.4.2.7	Parison Flashing	188
5.4.2.8	Neck Folds – Shoulder Cuts	188
5.4.2.9	Plastic Sticking to Core Rods	188
5.5	Troubleshooting – Thermoforming	191
5.5.1	Blisters or Bubbles	191
5.5.2	Incomplete Forming or Poor Detail	191
5.5.3	Sheet Scorched	191
5.5.4	Changing in Color Intensity or Blushing	191
5.5.5	Whitening of Sheet	192
5.5.6	Webbing, Bridging or Wrinkling	192
5.5.7	Nipples on Mold Side of Formed Sheet	195
5.5.8	Too Much Sag	195
5.5.9	Sag Variation between Sheet Blanks	196
5.5.10	Chill Marks or Mark-off Lines on Part	196
5.5.11	Bad Surface Marking	196
5.5.12	Shiny Streaks on Part	198

5.5.13	Excessive Post Shrinkage or Distortion of Part Removing from the Mold	199
5.5.14	Part Warpage	200
5.5.15	Poor Wall Thickness or Excessive Thinning in Some Areas	201
5.5.16	Non-Uniform Pre-stretch Bubble	201
5.5.17	Shrink Marks on Part, Especially in Corner Areas (Inside Radius of Molds)	202
5.5.18	Too Thin Corners in Deep Draws	204
5.5.19	Part Sticking to Mold	204
5.5.20	Sheet Sticking to Plug Assist	205
5.5.21	Tearing of Part When Forming	205
5.5.22	Cracking in Corners During Service	207
5.6	Troubleshooting – Rotational molding	207
5.6.1	Bubbles on Outer Wall	207
5.6.2	Discolored Part	208
5.6.3	Flash Excessive	208
5.6.4	Long Oven Cycle	208
5.6.5	Low Density Less Than Estimated	208
5.6.6	Poor Mold Filling	211
5.6.7	Poor Properties	211
5.6.8	Rough Inner Surface	211
5.6.9	Surface Pitting	213
5.6.10	Uneven Wall Thickness	213
5.6.11	Warpage	213
5.7	Fundamentals	215
	References	215
6.	Future Trends	217
6.1	Productivity	217
6.1.1	Reactive Approach	218
6.1.2	Proactive Approach	218
6.2	Automotive Applications	218
6.3	Medical Applications	219
6.4	Environmental Issues	219
6.5	Fundamentals	220
	References	220
	Index	221

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Preface

Plastics processing is a core technology in major sectors of the plastics industry. In spite of the growing importance of the field of plastics processing, a clear and uniform practical guide covering the entire field of troubleshooting of plastics processing has not been presented until now.

The Basics of Troubleshooting in Plastics Processing: An Introductory Practical Guide will appeal to all those who are involved in the plastics production sector. The material in the book covers both fundamental and practical aspects of plastics processing and attempts to provide the necessary background to understand the factors that constitute successful plastics manufacturing.

In an effort to mirror the goals of the plastics industry, the scope of the book emphasizes the importance of the high quality production of end products, processing, while deliberately restricting coverage of machine details to the main processing technologies. These technologies are: injection molding, extrusion, extrusion blow molding, injection blow molding, thermoforming, and rotational molding. By including fairly comprehensive details of technical information and reference material, this ensures the book is suitable for classroom and industry training purposes, without affecting its overall usefulness as a technical and reference work. It will be very suitable for research workers, engineers and operators in industry, students in plastics processing, as well as to all those seeking an introduction in plastics processing.

The framework of the book underscores both the book's academic and professional aspirations. Thermoplastics materials and characteristics are discussed in Chapter 2. A useful introduction of additives is covered in Chapter 3. The plastics processing techniques occupy Chapter 4 which also gives

information pertinent to troubleshooting. Chapter 5 deals specifically with troubleshooting problems and solutions and elucidates the various control measures available in plastics processing. Chapter 6 briefly presents the future trends related to plastics.

My major objective in writing this book was to provide a thorough background in plastics processing which is particularly important in order to increase the productivity and reduce wastage. Additionally, I hope this book will help people to develop the skills necessary to solve the problems in a stepwise manner.

I would like to thank Dr. A. Thamaraichelvan, and Mr. A.N. Sathagireesan for their encouragement. In addition, special thanks are due to my wife and sons for their support.

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Muralisrinivasan Natamai Subramanian

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1

Introduction

Plastics have become an integral part of our lives. Plastics are an excellent and very useful material and they are functional, hygienic, light, and economical. Using a key polymer processing system, plastics produce diverse products used in packaging, automotive and industrial applications, and also extensively used in medical delivery systems, artificial implants and other healthcare applications, water desalination, and removal of bacteria, etc.

Until the 1930s and in early 1940s, thermoplastics were not common material. Ever since the first industrial scale production of plastics (synthetic polymers) took place in the 1940s, the production and consumption has increased considerably. Although plastic materials are relatively new, they have become basic and indispensable in our life with different shapes, sizes, and applications that can be seen daily at home, office, and even on the street.

The growth in the manufacture of thermoplastic products for various applications has been considerably increased.

It includes many light engineering applications. The plastics materials usage for food packaging has obvious advantages associated with the non-toxic nature of these materials and their resistance to chemical and biological degradation [1].

1.1. Market Trends

Today, the requirements are constantly changing and rising to higher levels [2]. The world's annual consumption of polymer materials has increased from around 5 million metric tons in the 1950s to nearly 100 million metric tons today [3, 4]. The worldwide demand for plastic pipes is forecast to increase 4.6% annually through 2012 to 8.2 billion meters or 18.2 million tons. Demand for HDPE (polyethylene) pipes will benefit from use as small-diameter pipes in natural gas transmission, as conduit for electrical and telecommunications applications, and as corrugated pipes for drains and sewers [5].

The US market for plastic healthcare packaging is expected to reach 3.8 billion pounds of products in 2010. This amount is forecast to increase to nearly 5 billion pounds in 2015. PP (polypropylene) packaging, the largest segment of the market, will reach 1.3 billion pounds in 2015, after increasing by 6.3% per annum from the estimated 2010 total of nearly 1 billion pounds [6].

Global demand for PE, the largest-volume basic polymer, is expected to grow about 4.2% per year to reach about 81 million metric tons by 2013. Demand for engineering plastics will rise by 3.1% per year to reach 5.4 billion lbs by 2012. Polycarbonate, nylon, and ABS will continue to be the largest-volume engineering plastics, accounting for more than 75% of total demand by 2012 [7].

Polymer demand has been driven by high levels of investment particularly in packaging, appliances, consumer electronics, and automotive [8]. However, in the modern global market, quality is a key issue to remain competitive in business. Quality can no longer be simply the result of an inspection

process, but very much part of the strategic planning process of successful companies [9].

1.2 Importance of Plastics

Plastics are increasingly important in the manufacture of materials due to their significant higher strength to weight ratio and stiffness, as well as impact strength. The main drivers for the rapid increase in their use are low cost and the possibility of achieving total recyclability. But the large scale and widespread use of plastics is due to its low density and ease of processing.

Plastics are macromolecules derived from monomers, also called polymer. The word “poly” meaning many and “mer” designating the nature of the repeat unit [10, 11]. Polymers are from synthetic or naturally occurring material which can be used with modification to suit with respect to processing. The term “polymer” is these days known as “plastics” when referring to macromolecules like polypropylene, polystyrene, etc.

Plastics are constructed by the covalent linking of simple molecular repeated units [12]. Plastics are composed of carbon, nitrogen, oxygen, sulfur, chlorine, fluorine, and silicon. Moreover, plastics are made from petrochemical products which are a rich source of methane, ethylene, aliphatic, and aromatics. Variations in the elements make the plastic into stiff or flexible, linear or branched, and hard or soft.

Plastics are classified based on recyclability into thermoplastics and thermosets. Polyethylene (PE), polypropylene (PP), polyvinylchloride (PVC), etc., are some of the thermoplastics and phenol formaldehyde, urea formaldehyde, etc., are examples of the thermosets. Both thermoplastics and thermosetting materials may be molded and then cooled to obtain the end product. Thermoset once molded cannot be either softened or reprocessed.

Thermosets lead to products which are not recyclable. Moreover, it will form a network and it can neither be melted

nor reprocessed. Once shaped, it can be altered by post forming operations if required. Pre-polymers are to be made before processing in thermoset processing. However, thermoplastics soften while heating and solidify during the cooling process. Thermoplastics can be recycled by either direct heating or after grinding into granules of scrap products [13].

Processing technology that shapes material and technology of plastics allows the manufacture of parts with lightweight, precision and strength, and low cost. It is cheaper than metal or ceramic processing. However, to use plastic effectively and to have the best advantage of its application, specific characteristics or physical properties must be considered.

In plastics processing, with technology and application advances, conventional product replacement and unlimited innovation can take place. Plastic raw materials are also widening its range of products. Achieving higher performance with increased quality is the major challenge in manufacturing today. Plastics processing, therefore, requires constant and sometimes fundamental change.

Moreover, as plastics have replaced many conventional materials, such as metal and wood, in many applications throughout the world, the growth will be accelerated by the tendency to substitute plastics for metal [14].

1.2.1 Plastics vs Metal

When plastics are compared with metals, some of the properties of plastics can be considered either favorable or unfavorable depending upon the application. Plastics are not so strong as metal. However, plastics have certain properties to be considered as advantageous for engineering applications. Plastics have better chemical and moisture resistance. Plastics are more resistant to shock and vibration than metals. Plastics are usually easier to fabricate than metals. Nylon material is self-lubricating and does not require any external lubrication during operation.

Table 1.1 Materials properties comparison.

No.	Property	Plastics	Metals	Paper	Wood
1.	Density	Low	High	Low	Low
2.	Mechanical properties	Better	Good	Poor	Poor
3.	Chemical Properties	Good	Better	Poor	Poor
4.	Water resistance	Good	Corrosive	Absorb	Absorb
5.	Shock and vibration resistance	Good	Better	Poor	Poor
6.	Microbial resistance	Good	Poor	Poor	Poor
7.	Degradation	Difficult	Easy	Easy	Easy

1.2.2 Plastics vs Paper and Paper Board

Paper and paperboard are widely used as food packaging materials and have been used with a number of chemicals such as slimicides, bleaching agents, and inks during the production process. Virgin paper and paperboard products produced by pulping, bleaching, and treatment processes undergo severe chemical treatment and it is impossible to eliminate the chemical residue present [15–17]. Hence, migration of chemicals from paper packaging to the food is quick resulting in toxicity to humans as being the main concern.

1.3 Plastics Processing

Plastics processing requires the knowledge fundamentals of the raw material, additives, process control, and finally the product properties required to the finished end product. Today, polymer contains a package of ingredients to modify its properties while processing, or at its end product stage to create a new one.

In thermoplastics, processing techniques can be classified into either batch or continuous process. Batch processes

include injection molding, thermoforming and rotomolding. Extrusion of plastics is a continuous process. However, blow molding is available both in batch and continuous process. In these days, online continuous thermoforming machines are available along with extrusion process.

As the scientific techniques become available, the plastics processing is quickly incorporating the changes. However, new solutions pose new problems so these continue to be challenges to overcome. Troubleshooting helps to solve the problem at the root and increase the production efficiency during processing.

1.4 Fundamentals

- Based on recyclability, plastics can be divided into thermoplastics and thermosets.
- Knowledge of properties with respect to plastics raw material or its end product is essential to establish the trouble free plastics processing.

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2

Plastics Materials

Plastics material undergoes different and complicated thermo-mechanical processes. It experiences significant change in rheological, mechanical, and transport properties due to large variations and rapid cooling. The term “polymer” is preferred to “resin” when referring to a high molecular weight substance like polystyrene or polypropylene.

Plastics are:

- Made from chemical raw material composed of atoms of carbon in combination with other elements [1, 2] called monomers, which are basic materials including those made from coal, alcohol, natural gas and petroleum.
- Made up by the repeated addition of one or more types of monomeric units.

Plastics have progressed with invention efficiently and products can be manufactured economically. But various plastics